SECRETARY OF THE INTERIOR'S REPORT
To
The Advisory Council on Historic Preservation
In Accordance with Section 213 of the National Historic Preservation Act

Evaluation of the Proposed Mitigation Plans for the K-25 building on the Department of Energy's Oak Ridge Reservation, Tennessee

Building K-25, Oak Ridge, Tennessee, as originally completed.

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INTRODUCTION

The K-25 building, located on the Department of Energy's (DOE) Oak Ridge Reservation (ORR) in Oak Ridge, Tennessee, was the original gaseous diffusion process building for the enrichment of weapons-grade uranium under the top-secret Manhattan Project. Constructed between 1943 and 1945, the K-25 building began partial production of enriched uranium in February, 1945, and ultimately produced the uranium-235 assay (U^{235}) that, after further enrichment using Oak Ridge's Y-12 electromagnetic Calutrons, fueled the "Little Boy" atomic bomb dropped by the United States on Hiroshima, Japan, on August 6, 1945. The K-25 building continued to produce high-assay, weapons-grade uranium during much of the Cold War. As four more gaseous diffusion buildings—K-27 (1946), K-29 (1951), K-31 (1951), and K-33 (1954)—went into service at Oak Ridge, K-25 served as the final link in the multi-plant production chain that produced weapons-grade enriched uranium using gaseous diffusion alone. K-25 performed in this capacity until it and K-27 were shut down in 1964 following a presidential order to reduce the American stockpile of weapons-grade uranium. Its role was reduced to support of the remaining facilities in ORR's gaseous diffusion process from 1964 until the complete cessation of gaseous diffusion enrichment at Oak Ridge in August 1985. (Souza, DuVall, and Hart, 2001)

After consultation with Tennessee Historical Commission, the DOE found the K-25 building to be one of a number of nationally significant cultural resources related to both the Manhattan Project and to the Cold War; in 1999, the K-25 building was one of the three ORR properties designated by DOE as "Manhattan Project Signature Facilities" for their essential role in the interpretation of the Manhattan Project. In addition, the Oak Ridge Reservation is one of four separate and disparate, nationally significant areas that have been evaluated by the National Park Service in accordance with the Manhattan Project National Historical Park Study Act (Public Law 108-340) for potential inclusion in the National Park System (National Park Service, 2010). The DOE has proposed complete demolition of the K-25 building as part of the Department's Final Mitigation Plan for Site Interpretation of the East Tennessee Technology Park (ETTP), as the K-25 Site (K-25 and its immediate environs) is now known. On January 17, 2012, John M. Fowler, Executive Director of the Advisory Council on Historic Preservation (ACHP) requested that the Secretary of the Interior, acting through the Director, National Park Service (NPS), comment on "how the Department of Energy's (DOE) plans to remove the entire K-25 building at the Oak Ridge Reservation in Tennessee could affect interpretation of the property." The purpose of this Report is to address that specific issue only.

Authority for this Report

The National Historic Preservation Act (NHPA) as amended (16 U.S.C. § 470) and ancillary laws, regulations, and policies require that all Federal agencies manage historic properties as responsible stewards. Section 110 of the Act sets out broad affirmative responsibilities for Federal agencies to establish department-wide historic preservation programs to identify, manage, and maintain their historic properties. These regulations also provide for the ACHP, under Section 213 of the NHPA, to request a report of the

Secretary of the Interior (the Secretary), "detailing the significance of [the] historic property, describing the effects of any proposed undertaking on the affected property, and recommending measures to avoid, minimize, or mitigate adverse effects." This report furnishes the Secretary's response to the ACHP's January 17, 2012, request for an assessment of the impact of the DOE's mitigation plans for the complete demolition of K-25 building and of the impact of this proposed action on the interpretation of the ORR.

Project History

The United States Army, under the highly secretive Manhattan Project, oversaw construction of the K-25 building between 1943 and 1945. The K-25 building was fully operational by August, 1945. By spring 1946, after the end of World War II, the Army brought on-line a second facility for the isotopic enrichment of uranium, the K-27 building, which was tied to the K-25 building by process lines to allow the two gaseous diffusion cascades (sequential enriching stages) to operate in series. Because the Manhattan Project experienced such great success in the production of highly enriched U^{235} at ORR's K-25 facility, the U.S. Army's successor as the plant operator, the Atomic Energy Commission (AEC), continued to operate the K-25 industrial plant in the postwar years. In addition to the K-25 and K-27 buildings, the AEC oversaw construction and operation of new gaseous diffusion facilities at the K-25 Site (e.g. K-29, K-31, and K-33), as well as at Paducah, Kentucky, and Portsmouth, Ohio, that utilized technological advancements developed at the K-25 Site over the course of four decades. Research into gaseous diffusion technology continued at many facilities throughout the K-25 Site, including at the K-1037 Barrier Plant, where all diffusion-membrane barriers installed in diffusion cells at all DOE facilities in the United States were designed and manufactured.

As a result of President Lyndon B. Johnson's order to reduce the production of highly enriched uranium, the K-25 and K-27 cascades were shut down in 1964. While much of the remaining cascade at the K-25 Site was placed in standby, the site offered uranium-enrichment services to domestic and foreign customers under provisions of the Private Ownership of Special Nuclear Materials Act (1964) (Souza, DuVall, and Hart, 2001). To improve the efficiency of the gaseous diffusion process and to increase production capacity, the AEC's successor, the DOE, oversaw the removal, modification, and reinstallation of cascade equipment. Beginning in 1977, several cells in the K-25 and K-27 buildings were returned to service as a top-purge system for the entire gaseous diffusion process. In June, 1985, two months after celebrating the fortieth anniversary of dependable and continuous production of enriched uranium at ORR, the DOE announced plans to shut down the entire gaseous diffusion cascade. Later that summer, the last operating cell in the cascade was de-energized and the entire plant was placed in standby.

Since 1989, the K-25 Site, re-named the East Tennessee Technological Park (ETTP) in 1997, has served as the home of the DOE's Center for Environmental Technology and Center for Waste Management, as well as the base of operations for the Environmental Waste Management Program and the Reindustrialization Program. The overarching mission of the site is to reindustrialize and reuse site resources through leasing of vacated facilities and the recruitment of commercial industrial partners. As part of compliance efforts associated with this reindustrialization program, in 1994 the DOE engaged the Environmental Restoration Team from Brechtel Jacobs Company, LLC, to identify and evaluate properties included or eligible for inclusion in the National Register of Historic Places (NRHP) within ETTP boundaries. The team, in consultation with the Tennessee Historical Commission (SHPO) developed a historic context within which a period of significance from 1944 to 1964 was defined and concluded that a main plant area (K-25 Main Plant Historic District, comprised of 120 contributing and 37 non-contributing resources) and 11 individual structures outside of the identified district are eligible for listing in the NRHP. Among the resources identified were five gaseous diffusion process buildings (i.e. K-25, K-27, K-29, K-31, K-33), the K-1037 Barrier Plant, ten stations or portals along the site's historic security perimeter, and dozens of industrial and administrative support buildings and structures at the K-25 Site. In addition, in 2010 New South Associates concluded an archaeological survey and testing at the Happy Valley site, which housed 15,000 workers and families for the Manhattan Project's K-25 gaseous diffusion plant, and found these resources, now part of the proposed Heritage Center redevelopment site, to be eligible to the NRHP.

In 1994, the DOE's Oak Ridge Operations (ORO) Office entered into a Programmatic Agreement with the ACHP and the SHPO that called for the preparation of a Cultural Resources Management Report for the entire reservation; the CRM report was completed in 2001. In the interim, the DOE convened a Departmental Corporate Board on Historic Preservation, which recognized the importance of developing historic preservation and interpretive plans for Manhattan Project sites and for the fragile structural and artifactual resources associated with the World War II atomic bomb program. In 1999, the Board approved an initial list of "signature facilities" for the interpretation of the Manhattan Project, and the K-25 building is one of the three Oak Ridge resources, together with the X-10 reactor and the Y-12 Beta-3 race tracks, identified as a "signature facility." This finding effectively narrowed the interpretive focus for K-25 building to the Manhattan Project and the World War II era, excluding the Cold War significance of the building and its place in the broader cultural landscape of the entire K-25 Site. Many subsequent analyses, including the National Park Service's *Manhattan Project Sites Special Resources Study/Environmental Assessment* (2010), discussed K-25's potential contributions to the interpretation of an understanding of nuclear physics and applied sciences, the war effort, the ethics of weapons of mass destruction, the ramifications of nuclear proliferation, the effects of radiation, and the importance of scientific research to national security.

Consultation for the development of a Memorandum of Agreement (MOA) for the decontamination and decommissioning (D & D) of the K-25 and K-27 buildings commenced in 2001; the document, approved in 2003, required a third-party analysis of the preservation and interpretive strategies for those two buildings. In 2005, the DOE, the SHPO, and the ACHP entered into an MOA that included the retention of the North End Tower (aka North Wing, North End, North Tower) of the K-25 building and Portal 4 (K-1028-45), among other features, as the "best and most cost-effective mitigation to permanently commemorate, interpret, and preserve the significance" of the ETTP. Early the following year, as demolition of the K-25 building continued in compliance with the

2005 MOA, one of the contractor's staff fell through a deteriorated concrete panel of the North End Tower's operating floor, necessitating more stringent safety measures and resulting in increased rehabilitation costs. A series of consultation meetings ensued, and in 2009 the DOE advised that prohibitive costs and safety considerations precluded fulfillment of three stipulations in the 2005 MOA, including the preservation of the North End Tower. The parties offered a wide array of potential mitigation measures and, in the absence of consensus on how best to commemorate the K-25 building, the DOE, the SHPO, and the ACHP entered into a Bridge Memorandum of Agreement until the parties could reach a final agreement. After completing an evaluation of K-25's structural integrity (Degenkolb 2010) and interpretative approaches for the site (Informal Learning Experiences 2010), the DOE distributed a Preferred Mitigation Plan to the consulting parties in October, 2011. The DOE's Final Mitigation Plan, addressing comments submitted by consulting parties in November, 2011, permits the demolition of the entire K-25 building and calls for, among other mitigation measures, the designation of a commemorative area around the building's perimeter from which future surface development largely will be restricted; the retention, if possible, of the entire concrete slab or the demarcation of the building's footprint; the construction of a viewing tower and of a structure for equipment display; and the development of a History Center within the ETTP Fire Station.

The ACHP has requested this Section 213 report to assist the DOE and its consulting parties in considering appropriate measures to conclude Section 106 review and to focus on considerations critical to interpretation of the facility: namely, the remnants of the actual building, the array of diffusion process equipment, and the infrastructure necessary to the interpretation of the site.

Report Methodology

In response to the ACHP's request in late January 2012, the NPS assembled a multi-disciplinary staff working group to undertake an assessment of the impact of the DOE's mitigation plans for the complete demolition of K-25 building and of the impact of this proposed action on the interpretation of the ORR. The group included representatives from the NPS Southeast Regional Office, and the agency's Park Cultural Resources Compliance Office, the National Register of Historic Places/National Historic Landmarks Program, and the Historic American Engineering Record. The group reviewed and analyzed a broad range of documents related to the background, significance, and integrity of the K-25 Site, including the DOE's preferred and final mitigation plans. A list of the principal sources consulted for this evaluation is included at the end of the report. In addition, on February 6, 2012, representatives from the NPS staff working group conducted an on-site review at the ORR, inspecting the North End Tower of the K-25 building and touring the ETTP, as well as visiting the American Museum of Science and Energy (AMSE), the New Hope Center (on the Y-12 campus), and the K-25 Site (ETTP) interpretive overlook (south of the site, above Route 58).

FINDINGS

Historical Background and Significance

The Manhattan Project was an unprecedented, government-directed program implemented at a network of disparate sites within the United States during World War II to perform advanced nuclear-fission research and develop atomic weapons in advance of efforts in Nazi Germany. Among the most remarkable stories in American history, the project initially produced three bombs of unprecedented destructive power, two of which strongly influenced Japan to surrender without the need for a large-scale American invasion. Uranium refined at the "Clinton Engineering Works," (CEW) near Oak Ridge, Tennessee, and plutonium manufactured at a second reservation at Hanford, Washington, fueled the atomic bombs designed and assembled at the Los Alamos, New Mexico, laboratory, and dropped on the Japanese cities of Hiroshima and Nagasaki in August, 1945. This not only initiated the age of atomic weaponry, but the project also demonstrated the application of scientific research to the development of new technologies in a most dramatic fashion.

The Oak Ridge reservation, the most complex and expensive Manhattan Project installation, included three major industrial facilities that developed successful strategies for enriching U^{235} and for manufacturing plutonium (Pu^{239}), as well as a "Secret City" of administrative and support functions inhabited by a workforce that grew to nearly 75,000. This population, both civilian and military, constructed and operated ORR's industrial and research facilities in an isolated, high-security campus of nearly 60,000 acres. The ORR had major impacts on American society and on the role of the United States in the modern landscape of international politics and political economy during the six decades following WWII. As one of ORR's three "signature" facilities, the K-25 building is historically significant primarily for its direct association with the Manhattan Project, though its place in the K-25 Site's historic and cultural landscape also contributes to the broader interpretive themes for both the entire gaseous diffusion plant complex and the ORR as a whole.

On September 19, 1942, U.S. Army Corps of Engineers Brigadier General Leslie R. Groves inspected the Clinch River Valley, in eastern Tennessee, as a potential construction site for research facilities and production plants needed in the American efforts to develop an atomic bomb. The Army moved swiftly to acquire an area known first as "Kingston Demolition Range" and later as the "Clinton Engineering Works" (CEW). Code-named "Site X," CEW contained four disparate components: a town site (the present-day City of Oak Ridge), the X-10 Site/Graphite Reactor (present-day Oak Ridge National Laboratory, or ORNL), the Y-12 Electromagnetic Plant, and the K-25 Gaseous Diffusion Plan (present-day ETTP). The rural isolation of the Oak Ridge site, together with the natural ridge-and-valley topography of the area, concealed the entire operation and effectively compartmentalized each component in this high-security environment. By 1945, more than 6,000 security officers policed the reservation, where every resident over 11 years old was required to wear an identity badge, and where virtually all plant employees worked under a "need-to-know" basis. (Johnson and

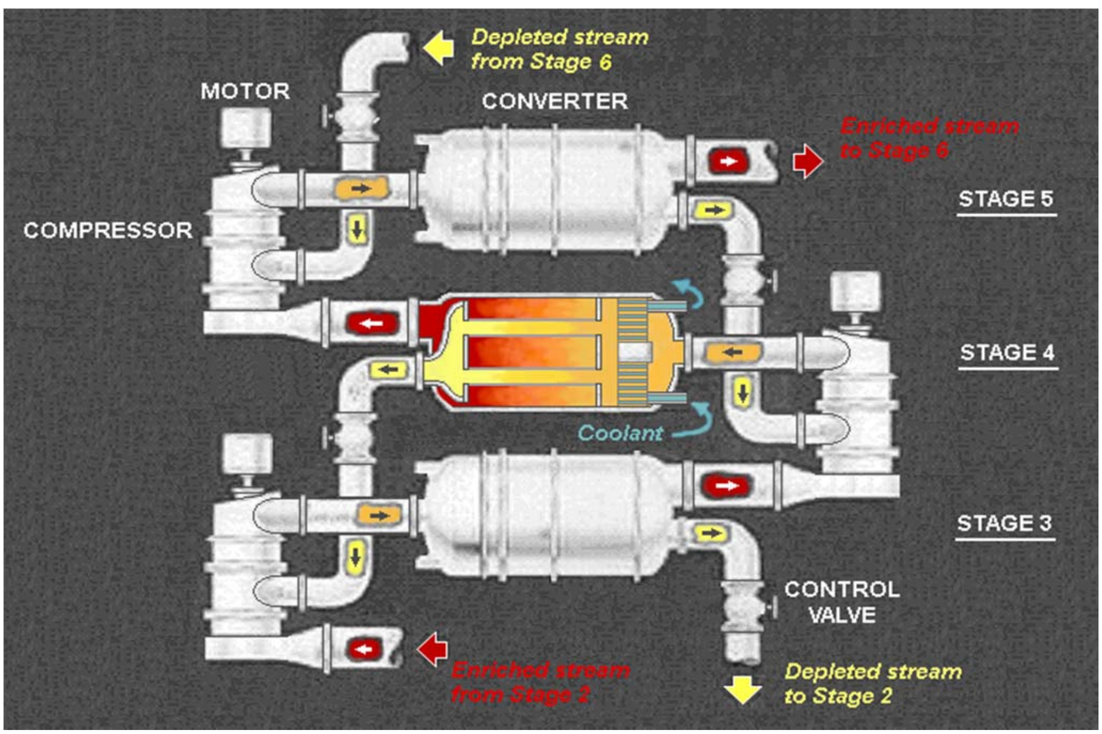
Jackson, 1981).

The K-25 building is nationally significant on an individual basis for its association with the development of a technology providing for the separation of uranium isotopes through the gaseous diffusion process and with the production of enriched uranium (i.e., uranium having substantially more than the naturally occurring 0.7 percent of the U^{235} isotope) on an industrial scale for the first time. Construction of the K-25 building began in September, 1943. When completed in 1945, the K-25 building was the largest and most costly industrial plant ever erected (Jones, 1985). As constructed, the overall footprint of the half-mile long, essentially U-shaped facility comprised of large, rectangular East and West wings and the smaller, roughly square North End Tower. As a whole, the facility cost almost $500 million to construct and occupied 42.6 acres. (Rhodes, 1986).

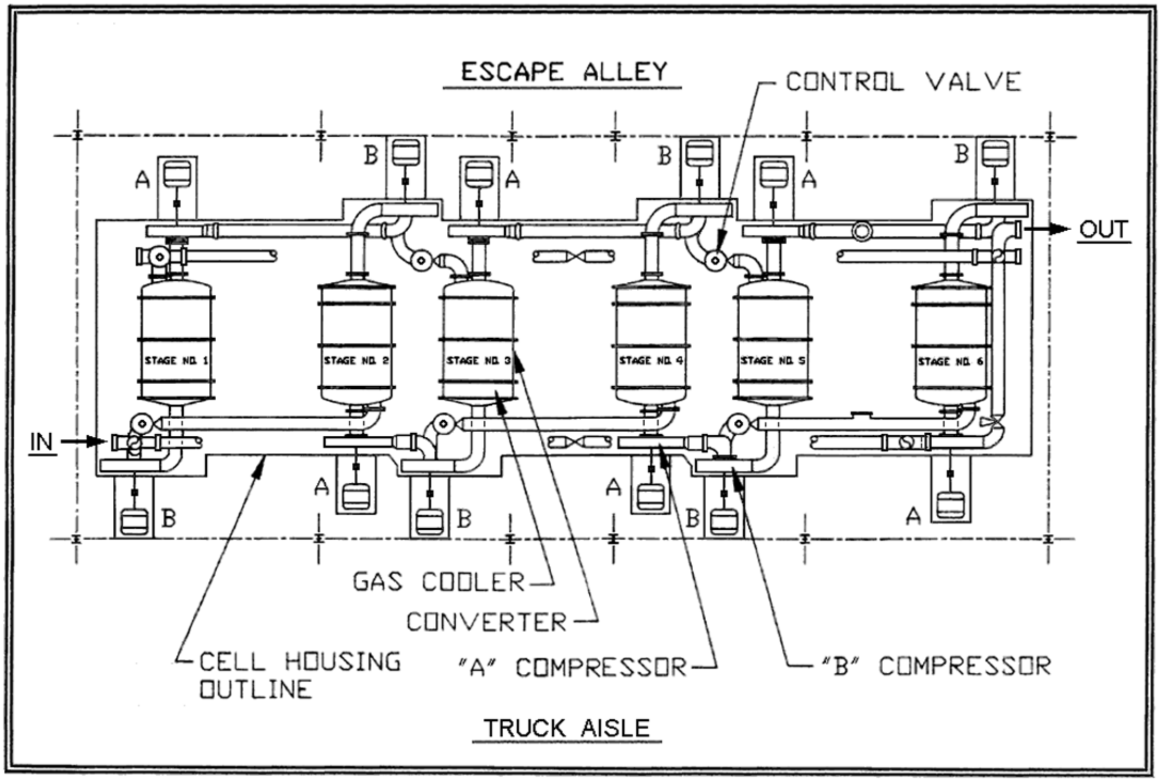
This 1940s view of K-25's West Wing shows the repetitive nature of the building. Each unit, identified by a projecting stair tower, typically contained eight cells of six converter stages, though some had other configurations.

The K-25 building was designed and built to produce enriched U^{235} utilizing a multi-stage, cascade-on-cascade gaseous diffusion process. The gaseous diffusion process involved separating uranium's fissile isotope U^{235} from the heavier, more-stable U^{238} isotope that makes up over 99 percent of uranium in its natural state. U^{235} and U^{238} are chemically identical, so they cannot be separated by any chemical process. With each U^{235} atom having three fewer neutrons than the predominate U^{238} atoms, its mass is about 0.9 percent less, making the mass of each uranium hexafluoride (UF_6) molecule slightly less as well. This allows separation of the isotopes using mechanical techniques, including gaseous diffusion. The gaseous diffusion process uses uranium hexafluoride, which is a gas near atmospheric pressure and at temperatures above approximately 57 C (134 F), and a semi-permeable "barrier" with millions of pores measuring approximately 10 billionths of a meter in diameter (m x 10^{-7}) to separate the two isotopes. At the time, developing this barrier technology was a remarkable, if not monumental, achievement in and of itself (Rhodes, 1996). The lighter U^{235} atoms make lighter UF_6 molecules that are slightly more likely to penetrate the barrier than the heavier UF_6 molecules formed with U^{238} atoms, so the gas passing through each barrier has a slightly higher (approximately 0.1 – 0.3 percent) concentration of U^{235} that is termed "enriched." For significant enrichment, this process must be repeated several thousand times (Smyth, 1945). The uranium hexafluoride gas for K-25 was produced using a multi-step chemical process, and the U^{235} was chemically separated from the fluorine after the enrichment process.

As the enrichment level increased, the volume of UF_6 gas passing through the cells was reduced to improve the process efficiency, and this allowed the use of smaller converters and compressors. The figures that follow show two different types of compressors and slightly different converters that were designed to handle different volumes of gas, but the process is the same in both. Over time, at least four different sizes of converters and compressors were utilized in the site's five gaseous diffusion plants.



This drawing shows how three converter stages (one-half of a typical cell) were connected. The red UF_6, flows are enriched, the yellow flows are depleted, and the orange flows are a mix. A liquid coolant removed the heat of compression at each stage to maintain the UF_6 at its optimum temperature. This arrangement was repeated to interconnect almost 2,900 converter stages in K-25. K-27, K-29, K-31, and K-33 used similar cascades.



This drawing shows six converters arranged in a cell. The basic process piped enriched uranium hexafluoride from one stage to the next, while the depleted gas was routed to the previous stage. This cell shows a different compressor design than the previous figure, but it functions the same way. With all of the possible recirculations, a UF_6 molecule could encounter over 100,000 barriers in its journey through K-25.

The basic production unit of the gaseous diffusion process was a "cell," most of which contained six converters (some cells were differently equipped). A compressor pumped uranium hexafluoride gas (UF_6) into the first converter (Stage 1), where a cooler removed the heat of compression and passed the gas to the diffuser section, essentially a tank within a tank. The barrier separated the two portions of the tank, and each portion had a separate exhaust. A second compressor transferred the slightly "enriched" UF_6 to the inlet compressor for the Stage 2 converter, where the process was repeated with its enriched UF_6 gas passing to Stage 3, and so on through Stage 6 in most cells. The UF_6 with slightly less U^{235}, known as "depleted," was recirculated and blended with enriched UF_6 at each stage to maintain the proper volume of gas throughout the system and to provide another separation opportunity. Similarly, the enriched output of one cell became the input of the next one.

As the amount of enrichment resulting from any single stage of the diffusion process was miniscule, the production of useful amounts of highly enriched U^{235} necessary for weapons, or even the far less-enriched variety suitable for energy production, required repetition through thousands of converter stages. These stages were connected by over 100 miles of pipes arranged to ensure that the enriched and depleted streams of gas flowed properly between converters. Retention of the extremely valuable product, protection of equipment, and personnel safety required an absolute minimum of leakage throughout the extensive system. To complicate matters, UF_6 reacted with even the slightest amount of water to produce very corrosive compounds, including hydrofluoric acid (HF), that attacked most metals. Since much of the system operated below atmospheric pressure, inward leakage would introduce water vapor contained in the air, and the corrosive compounds formed would spread rapidly and could cause extensive damage. To accomplish the high degree of quality required careful selection of materials that resisted corrosion, and except where necessary for maintenance access, the pipe joints were welded. When maintenance was necessary—particularly to repair leaks—valves provided the ability to bypass problematic converters or cells.

In January, 20, 1945, the first gaseous diffusion equipment went on-line and the K-25 building began partial production of enriched uranium. The entire building became fully operational in August of that year, producing a top-product U^{235} assay of thirty percent that was then sent to the Y-12 Beta Calutrons for further, electromagnetic enrichment. At its completion in March 1945, the K-25 building's cascade employed a total of 2,892 original converter stages. (Jones, 1985, Rhodes, 1986)

The U-shaped building, with corrugated, asbestos-cement siding over masonry walls and a structural-steel skeleton, housed 54 units under a single roof. The building had three floors, designated as the basement, cell, and operating floor levels, totaling 4.75 million square feet of floor space, as well as an intermediate level of open-grate walkways in the upper portion of the cell level that was designated as the pipe gallery. On the cell level of the building's three wings, cells were lined up in two parallel rows facing a truck aisle that extended the 300-to- 400-foot width of each building (thirteen sections in the East Wing were narrower), placing them perpendicular to the long axis of each wing. The equipment in one cell in Unit K-303-7 in the East Wing was painted with color-codes to identify individual components for the very few visiting dignitaries. A basement (or vault level) below housed mechanical and electrical support equipment. On the building's operating level, which housed most of the monitoring and control devices and panels for the plant, the cells and units were generally not separated by partitions, though some enclosed offices were located there. Most plant employees worked on the operating floor, but some worked throughout all levels of the K-25 building during operation and maintenance; they were often subjected to rigorous conditions, including heat generated by the equipment and processes that was coupled to the region's high temperature and humidity during the lengthy summers.

Although intimately familiar with their own jobs, virtually none of the CEW workforce knew anything about the overall purpose of their work. They, like most Americans, were surprised to learn of the connection of the work at Oak Ridge to the "Little Boy" bomb dropped on Hiroshima. The mission of the K-25 Site continued throughout much of the Cold War period. A second gaseous diffusion plant, Building K-27, began full operation in 1946, and a third plant, Building K-29, was completed in 1951. Similar, though more modern, Buildings K-31 and K-33 were completed in 1951 and 1954, respectively, lengthening the cascade through piping connections among these five facilities. In addition to the process buildings, other structures at the K-25 Site housed significant research (e.g. the K-1037 Barrier Plant, where scientists and engineers developed and manufactured the membranes critical to the viability of the gaseous diffusion process) and support functions (e.g. water towers, a cafeteria, a laundry, storage and instrument shops). Ultimately, the site contained more than one-hundred buildings during the course of its forty-year mission. In 1964, production of U^{235} in the K-25 and K-27 cascades was discontinued. The last cell at the K-25 Site was de-energized on August 7, 1985 (Souza, DuVall, and Hart, 2001).

Integrity

The K-25 building was built near the southwestern edge of the Clinton Engineer Works (Oak Ridge Reservation), slightly west of the junction of Blair Road (TN Rt. 327) and Oak Ridge Turnpike (TN Rt. 58). At the time it was completed in 1945, the K-25 building ranked among the largest buildings in the world. By January of 2010, all of the building's original, 884,000-sq.-ft. West Wing had been demolished, leaving only the wing's concrete slab for possible retention. The DOE is currently overseeing the demolition of the building's original, 796,000-sq.-ft. East Wing. The ultimate disposition of the concrete base pads, the only anticipated structural remains of the K-25 building's massive East and West Wings, awaits a final decontamination analysis.

By September 2010, K-25's West Wing was gone and crews had begun to demolish the East Wing, starting near its south end and working northward (view from northwest).

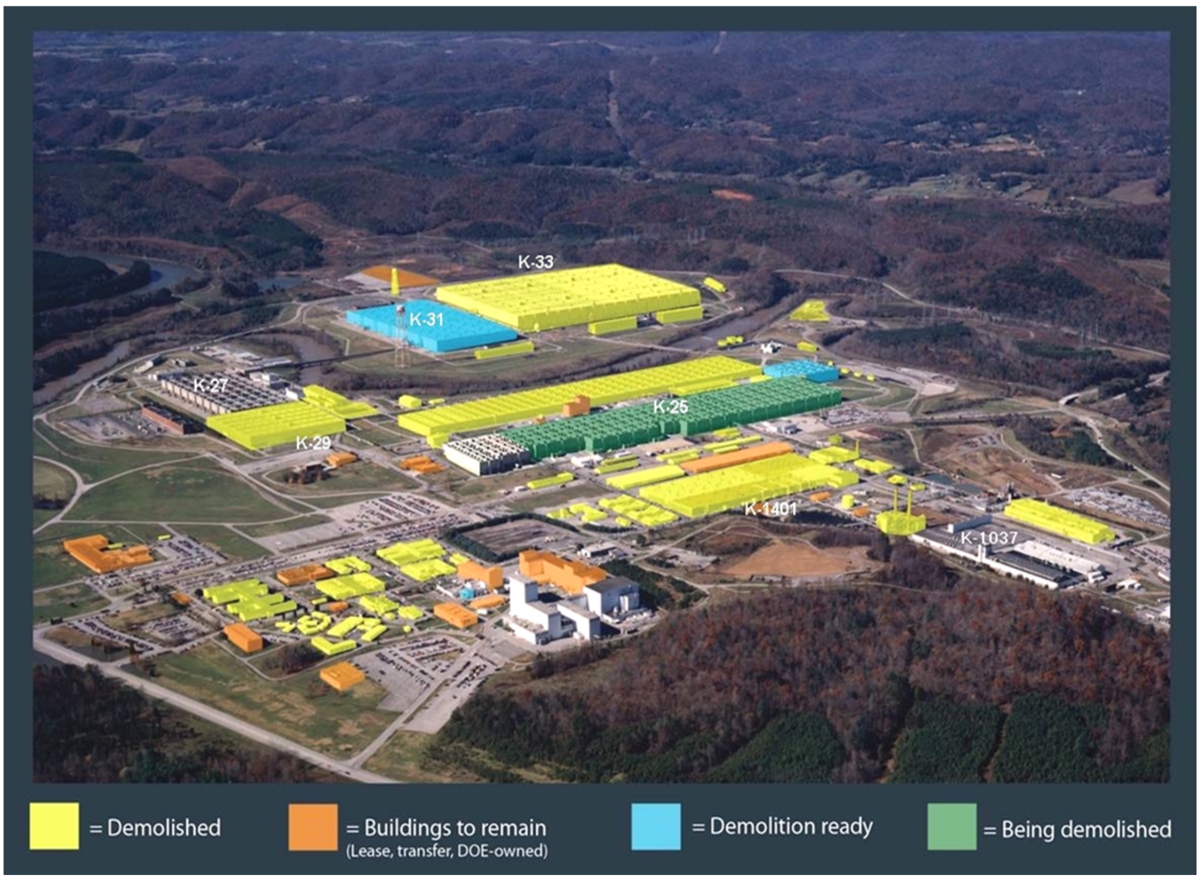
The loss of the K-25 building's large West and East Wings constitutes a significant diminishment of the original building's overall historic integrity. However, from the standpoint of historic interior and exterior fabric, purpose, function, equipment, and interior layout, K-25's surviving, still sizable (approximately 110,000 sq. ft.) North End Tower remains a relatively intact, tangible representation of the historic significance embodied in the much larger original plant, particularly when considered from an interior perspective.

While nearly all original mechanical process support equipment has been removed from the basement level of the North End Tower, the building retains its original concrete slab on grade, as well as its original reinforced concrete piers and beams that support the building's original steel framework. Over two dozen of these piers exhibit serious damage and have been bolstered using temporary steel columns. The first floor—the cell level—continues to support virtually all of its original cells containing converters, compressors, and associated equipment. Most of these remain in their original locations and are in reasonably intact physical (albeit, not necessarily cosmetic or operable) condition. The cells are mounted on original, raised-concrete slabs that rise 3 ½ feet above the truck aisle. In the North End Tower of the K-25 building, the original truck and escape corridors extend over 300 feet from one end of the building to the other on a north-south axis.

Immediately above the North End Tower's cell floor at the pipe gallery level, the primary structure consists of original, structural-steel columns and beams. This level is dominated by a spider web of original process piping, manually operated valves, and open-grate, steel access catwalks. The original jacketing and asbestos-containing insulation have been removed, revealing pipes in generally good condition. The operating floor level and the roof deck are likewise framed with original, structural-steel columns and beams. The operating floor deck consists of lightly reinforced, original, precast concrete planks that rest on the steel beams. These are in very poor condition. The roof surface consists of poured gypsum slabs with bulb tees spanning between the steel beams. The built-up roof surface it supports has numerous leaks. Exterior walls above the cell floor are corrugated asbestos-cement panels attached to steel wind girts and steel studs that are, in turn, attached to masonry comprised of an admixture of substantially intact concrete block, cinder block, and large-dimension-brick infill. The North End Tower as a whole also retains numerous original expansion joints in both the concrete and steel framing levels.

While from a historic standpoint, the North End Tower remains substantially intact, advanced roof deterioration has led to significant, long-term moisture problems throughout the building, resulting in the extensive pooling of water at the cell floor and raised gallery levels, as well as hazardous levels of mold throughout the interior as a whole. Most significantly, the current structural integrity of the building's basement level appears problematic. Structural inadequacy is evidenced by vertical stress cracks in more than two dozen of the large, reinforced-concrete piers that support the first-floor's concrete beams. Most of these cracks are in corbels that support the ends of the floor beams. This condition is currently stabilized via the installation of temporary, steel Lally-column screw jacks adjacent to the failed beams. Permanent remediation of this problem is highly likely to have a significant adverse effect on the historic fabric and/or character of the North End Tower's basement level as a whole.

The loss of much of the K-25 Site's cultural landscape represents an additional compromise to several aspects of the K-25 building's integrity, including setting, function, association, and feeling. The past two decades have witnessed the demolition of more than two dozen buildings and structures within the main plant area, including gaseous diffusion buildings K-33 and K-29. Other production facilities, such as the K-27 and K-31 buildings, are currently slated for demolition, and the fate of key resources, such as the K-1037 Barrier Plant, seem far from certain. While many of these resources post-date the Manhattan Project, they contribute to the site's Cold War context and represent an important theme in the interpretation of the K-25 Site as a whole. Moreover, the removal of many elements of the historic security perimeter, together with the construction of new facilities within the cultural landscape, present additional challenges to the interpretation of both the K-25 building and the larger K-25 Site.



Partial view from the southeast of the former Clinton Engineer Works (now East Tennessee Technology Park) at Oak Ridge, Tennessee, showing current (2012) status of buildings.

<u>Recommendations for Retention of Building Remnants</u>

After consultation with the SHPO, the DOE found the K-25 building to be one of a number of nationally significant cultural resources related to both the Manhattan Project and to the Cold War; in 1999, the K-25 building was one of the three ORR properties designated by DOE as “Manhattan Project Signature Facilities” for their essential role in the interpretation of the Manhattan Project. For nearly two decades, the DOE and the stakeholder parties with which it has consulted have labored to fulfill the agency’s commitment to commemorate and to interpret the K-25 building. While the various consulting parties brought different perspectives and, consequently, different recommendations to the discussions with regard to the scale, costs, and approaches to preserving K-25’s history and significance, all parties affirmed the importance of a visitor experience that included access to the site and to as much of the original fabric as is possible to retain.

The K-25 building has no substitute. It is vital that the maximum practical amount of the original building and equipment be preserved to enable the best possible interpretation of this facility and its operation. There is no question among the vast majority of historians that there is significant value in location. Being at a historic site or, especially, inside a historic structure gives visitors of all levels of knowledge a sense of “being there” that reproductions cannot fully emulate. Almost invariably, even good reproductions alter or omit details to some degree. While this may not bother most visitors—largely because they will never know what they could not experience—it significantly degrades the display’s usefulness as a scholarly resource, and the other DOE gaseous diffusion facilities at Oak Ridge and elsewhere have been, or soon will be, demolished or converted to other processes. This will render any remaining portion of K-25 building the sole surviving facility anywhere for hands-on historical interpretation and research of the gaseous diffusion process and its significance during World War II and beyond. Thus, while the present physical condition of the building may argue for its total demolition, the tremendous historical significance of K-25 argues for the opposite.

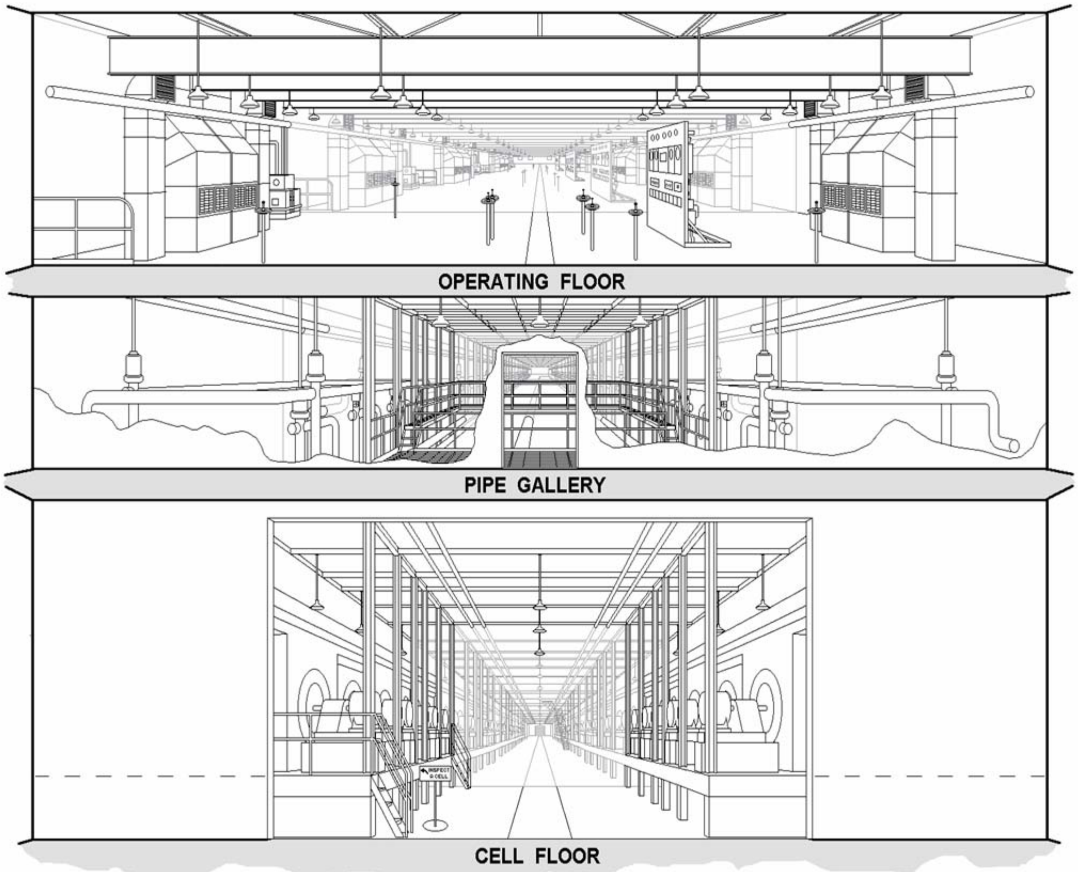
The concept of “authenticity” cannot be overstated in the preservation and interpretive planning for K-25. In this regard, there are two foci critical to an adequate interpretation of the K-25 building and to the resource’s ability to convey its own technological significance as well as its contribution to the overall historical significance of the Manhattan Project.

First is the interpretation of the gaseous diffusion process, including the equipment, methods, how gas was routed within, between, and around cells and individual converters, and how the process was monitored and controlled. Although such an interpretation can be provided in a variety of settings, the *in situ* arrangement has all of the components, including a multitude of details, as well as their correct orientation to one another, and therefore retains the highest possible levels of historic integrity in terms of location, design, setting, materials, workmanship, feeling, and association.

Second is the ability to provide an effective interpretation of the worker experience when the plant was in operation. The DOE and its consulting parties, as well as the NPS, found that to immerse a visitor in the experience of plant operations and the complex, repetitive nature of the gaseous diffusion process will require retention of a minimum of two cells and the truck aisle between them on the cell level, as well as the corresponding pipes and control devices on the pipe gallery and operating levels. Ideally, this would be four cells on each side extending along the full 300-foot length of the truck aisle, including the complete pipe gallery and operation floor, to convey the size of the facility [Degenkolb, Option 1], but the DOE and its consulting parties have already agreed that retention of more extensive portions of the North End Tower is impractical. Retention of a two-cell arrangement provides for *adequate* interpretation of the gaseous diffusion process and of the worker experience in plant operations

With the two-cell arrangement noted above, several available techniques could be used to simulate the remaining portion of the 300^{+}-foot length of each level at one end of the display, with visitors entering—or at least viewing—each level from the other end. This presumes new construction of a combination entrance and exhibit structure that would provide ADA-compliant access to all three levels, along with rest rooms, offices, and spaces for other necessary and desired services.

Since virtually all of the significant process support equipment in the basement level of the North End Tower has already been removed, this level need not be physically presented or available for unlimited public access. Thus, new permanent steel supporting structures could be erected to fully support the cell level and above if a portion of the original building is retained, which would likely be significantly less expensive and far more dependable than any attempted repair of the existing concrete structure. Such an arrangement would likely leave a substantial portion of the basement useable for storage and/or utility equipment, as well as allowing scholars and others with a serious interest in the building's original construction safe access when needed. An approximation of what visitors would see at each level with this display concept is shown in Figure 1.



BLACK – Hardware
GRAY – Graphics

NOT TO SCALE

NOTES:

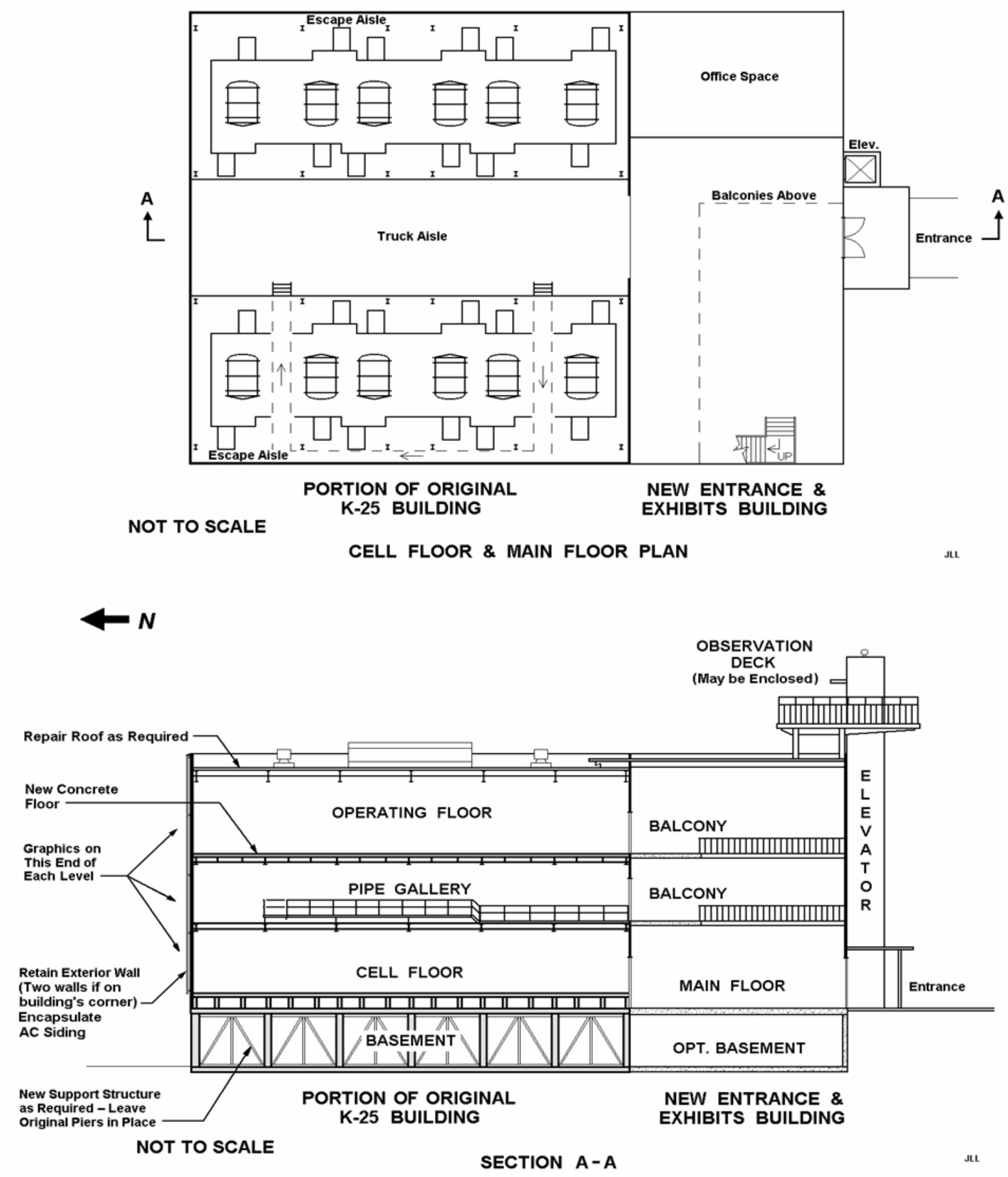
1. Basement Level will not be open for public access, so no view of it is shown.
2. Entrance & Exhibits Building will provide ADA-compliant access to all floors and all offices & services.

JLL

ALL CONCEPTS – VIEWS THROUGH OPENINGS FROM NEW ENTRANCE & EXHIBITS BUILDING.

Figure 1

An observation deck, situated at the top of the elevator tower, would afford a panoramic view of the K-25 building's entire footprint and of much of the surrounding cultural landscape. This *in situ* two-cell arrangement with a new entrance and exhibit building (Concept A) is shown in Figure 2.

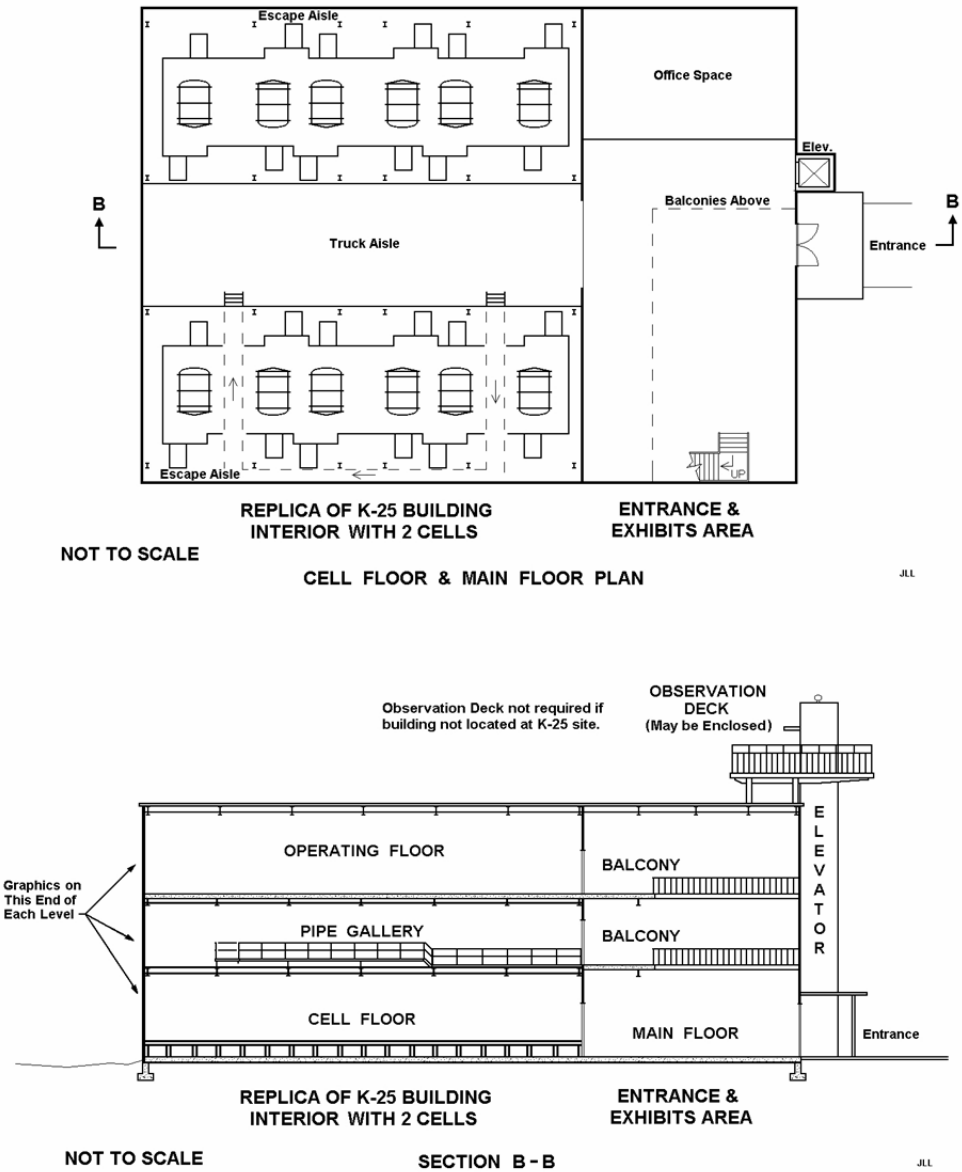


CONCEPT A – Retain 2 complete cells (all levels & original roof) of K-25 North Building *in situ*, and erect new entrance & exhibits building adjacent to K-25 North Building.

Figure 2

Figure 2 is strictly a conceptual drawing, so the size, plan, and style of the new construction could vary widely from what is shown, and issues such as emergency egress and utilities are not addressed.

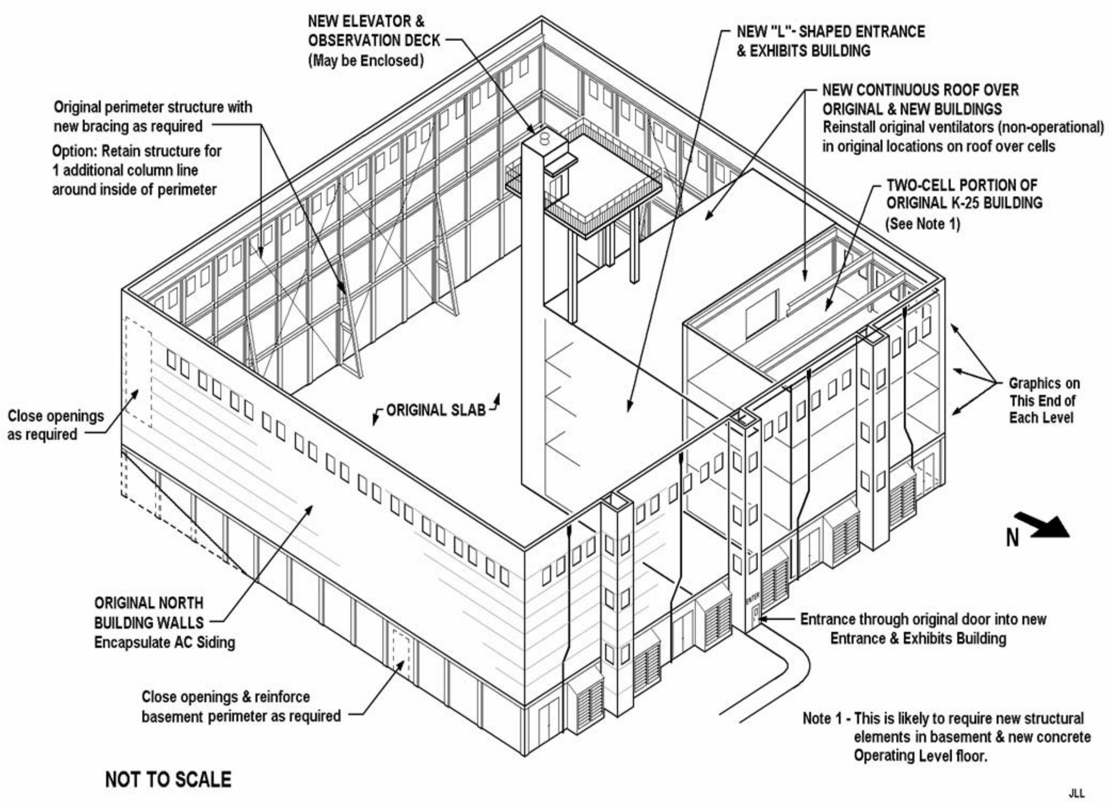
The same two-cell arrangement provided for in Concept A could also be replicated within an entirely new structure (Concept B), as shown in Figure 3.



CONCEPT B – All new construction, at K-25 site or elsewhere, with all equipment, including pipes, of 2 complete original cells relocated in a replica of the original K-25 North Building interior.

Figure 3

A third design (Concept C) would utilize the *in situ* two-cell arrangement described in Concept A above, but also retain all of the exterior walls of the North End Tower of the K-25 building and locate the new entrance and exhibits building within that footprint. While this proposal depicted below allows for demolition of over 91 percent of the North End Tower's interior and its entire roof, it will require some repairs to the walls and the perimeter of the basement (including six failed piers). New wind bracing for the walls will likely be needed as well, which could be accomplished in several ways. A contiguous new roof would cover the original and new structures inside the footprint to minimize leakage and maintenance. This "preferred-alternative" concept would allow visitors to see the size and appearance of the North End Tower of the K-25 building as they approach it at ground level, and the visitors would enter the building much the way many K-25 workers did. (An elevated, ramped walkway from the new entrance and exhibits structure's top floor to a deck inside the south exterior wall could be substituted for the elevated observation deck to provide an overall view of K-25's complete footprint. This would remove any possible compromise of the North End Tower's external appearance on the ground level.) This conceptual alternative is illustrated in Figure 4.



CONCEPT C – Retain 2 complete cells (all levels & original roof deck) & all exterior walls of K-25 North Building *in situ*, and erect new entrance & exhibits building within the original footprint of K-25 North Building.

Figure 4

The advantages and disadvantages of the three design concepts are summarized in the Table 1.

Table 1. Comparison of Design Concepts for Remnants of Historic Fabric

	Advantages	Disadvantages
Concept A (*in situ* retention of four-level building section)	Preserves original setting Retention of considerable historic fabric, including a small portion of the building's exterior Historically accurate display of equipment on all levels Physical connection with building footprint provides site context, including accurate orientation to Portal 4 On-site interpretation provides experience of broader ORR context (e.g. compartmentalization of facilities) Reduction of some demolition costs	Requires substantial repairs to retained portion of the building Necessity of radiological and biological decontamination Expense and design challenges associated with meeting current structure, fire and life-safety regulations without further compromising building integrity Potential need for asbestos abatement if asbestos-cement exterior panels are retained Relatively high long-term maintenance costs
Concept B (least-favored alternative given all factors: all-new structure containing historic equipment)	Flexible setting (construction at K-25 or elsewhere) Relative ease in meeting structure, fire, & life-safety codes Decontamination required only for equipment and pipes No unique interface between the old & new structures required New structure could replicate building length, permitting experience of historic scaling Reasonable to estimate expected life & projected maintenance costs	Loss of all historic structural fabric Potential for omission or incorrect installation of equipment, piping, controls, & associated details Potential for inaccurate or inauthentic experience of architectural details Expense of retrieval & storage of additional equipment for expansive facility Loss of context if alternative site is chosen
Concept C (**best alternative** given all factors: *in situ* retention of four-level building section & perimeter walls)	Same as Concept A (except second point) Retention of maximum practical historic fabric Experience of North End Tower's vertical size Relatively accurate exterior façade Likely use of original slab for entrance & exhibit structure Possibility of future use of original slab for additional exhibits or other related uses Contiguous roof over original & new structures minimizes maintenance costs	Same as Concept A Preservation of exterior walls may restrict internal demolition techniques Long-term maintenance costs difficult to determine

NPS does not recommend display of disconnected examples of each major process device in an open-air pavilion (Degenkolb, Option 3). Even with a roof, the exposure would result in rapid deterioration of the extraordinary equipment, not to mention its vulnerability to intentional damage. Additionally, there would be no physical presentation of the complex interconnections between converters and cells, an essential element of any interpretive effort. Enclosing this pavilion (Degenkolb, Option 4) would largely prevent equipment deterioration, but this would suffer from the same presentation and interpretation difficulties.

Because the K-25 building has no substitute, the NPS considers it vital that the maximum practical amount of the original building and equipment be preserved to enable the best possible interpretation of this facility and its operation. Retention of the two-cell arrangement constitutes the absolute minimum amount of equipment needed to properly illustrate and interpret the gaseous diffusion process. This would preserve approximately one-twelfth of the original North End Tower of the K-25 building and less than 0.3 percent of K-25's original converters. Retaining the exterior wall of the North End Tower in addition to the two-cell arrangement would confer a sense of mass and volume that is otherwise unavailable, and present the only truly appropriate façade for a compelling K-25 experience.

Adequate interpretation of the K-25 building also requires a comprehensive design solution for demarcating the building's overall, original, U-shaped footprint. Retention of K-25's concrete slab in its entirety, if possible, should be part of an interpretive strategy that aims to convey the scale of the historic structure and of the operations housed within the Manhattan Project's massive gaseous diffusion plant.

Recommendations for Retention and Display of Diffusion Equipment

While the recommendations above for the retention of portions of the K-25 building include a discussion of the types of diffusion process equipment vital to the interpretation of the site, some expansion is warranted. This discussion assumes that one of the concepts described above that includes two complete cells across a truck aisle will be adopted.

The process equipment displayed should include the following for each cell:

The six (Stage 1 through Stage 6) gas cooler-converter assemblies
The six "A" compressors, including their motors and couplings
The six "B" compressors, including their motors and couplings
All UF_6 piping within the cell, including all control and shut-off valves and fittings
The cell housing, though portions would likely be opened for viewing
The manual valves and control panels for the cell located on the Operating Floor

Additional elements needed for an accurate display include:

Ancillary fixtures, such as period light fixtures and ventilation devices
At least one of the Operating Floor windows and stairwell doors
At least one example of genuine desks, chairs, bicycles, etc. normally used
Other significant piping that supported the operation

While these elements will allow for adequate interpretation of the operation of a single cell, they cannot illustrate how the various cells were inter-connected to provide for normal operation, cell isolation for maintenance, or alternate connections used to suit specific conditions. This will require a minimum of two cells, and they should be arranged as they are over the building's three levels to furnish a useful sense of the work environment. As stressed previously, having the proper spatial orientation of the equipment and piping is vital. Visitors who are not familiar with engineering drawings or who have poor spatial-visualization skills will need to see the piping and inter-connections as they existed to gain any appreciation of the design challenges and solutions.

NPS understands that there were four different sizes of converters used in the K-25 building, as well as in the other gaseous diffusion production facilities (i.e. K-27, K-29, K-31, and K-33) at the site. At least one of each size should be preserved if possible. In addition to retaining important historic fabric, these could be used to help explain how the UF6 gas volumes were changed as enrichment increased. Different size compressors were used with these converters, and some were of a different design. Though not essential, consideration should also be giving to preserving one of each variety in support of the interpretive themes for ETTP, including the significance of the K-25 Site in Cold War-era atomic research and production.

If permitted by security requirements, one gas cooler-converter assembly should be quarter-sectioned and paint coded to show its internal arrangement and explain how it functioned. This will, of course, require DOE approval in general, and, if permitted, DOE-approved substitutes for the actual separation barrier and seals, which remain classified. This “demonstration” assembly could be one of the units installed in a cell exhibit or as a separate display. Along this same line, and particularly so if a sectioned display is not possible, the unique purpose and markings of the so-called “Roosevelt Cell” in Unit K-303-7 argue strongly for its preservation and display.

NPS does not know whether any of the pilot equipment used to prove and refine the process still exists, though this is doubtful since the pilot lines were primarily built in university laboratories. If anything does exist, and DOE will allow its display, that would be the equipment to exhibit, along with a discussion of process-development challenges. If such exists and DOE will allow its display, one or more examples of early, unsuccessful barrier material would be very useful in interpreting the development saga. Otherwise, photographs (hopefully) and text will have to suffice. Numerous photographs exist to illustrate the logistical challenges of construction. It is very unlikely that any of the actual construction equipment survived, but, if so, finding and authenticating it likely would be very difficult. If no portion of the original building is preserved, samples of the actual construction materials should be retained for display. Logistical problems may also be supported by key records and/or correspondence.

<u>Additional Interpretive and Mitigation Considerations Specific to Building K-25</u>

NPS considers one type of mitigation to be essential for adequate interpretation of the K-25 building, particularly since its partial demolition is already a reality and further demolition is underway: the K-25 building, Portal 4 (K-1028-45), and K-1037 buildings should be documented as extensively as possible by a Level I Historic Documentation Program, including a written description and history, archival-quality photographs, historic photographs, and drawings, executed to meet the requirements of the Secretary of the Interior’s *Standards and Guidelines for Architectural and Engineering Documentation*. This should encompass the entire building, including what has already been demolished, to the maximum extent that available data support. Obviously, this would exclude any elements that remain classified, since this documentation becomes part of the Library of Congress's public domain collection. This can be accomplished in several ways, including the use of in-house personnel, engaging private contractors, or engaging the Historic American Engineering Record (HAER, who prepared the engineering standards), but if an organization other than HAER is used, the inordinate significance and uniqueness of the K-25 building makes it vital that HAER reviews the draft documentation early and often enough to ensure compliance with the Secretary's Standards before the available resources are exhausted.

Normally, the preferred method for producing drawings is to measure the existing building's interior and exterior on site and generate the drawings based on those dimensions, but beside the security concerns, the K-25 building presents several barriers to this method. Approximately two-thirds of it has already been demolished, and known physical, radiological, and biological hazards exist within the remaining portions, which are currently undergoing demolition. These make it necessary to eliminate, or at least minimize, personnel exposure at the site. HAER would utilize alternate methods which it has employed on certain other projects. If the construction, alteration, and maintenance drawings DOE can provide are sufficient, most needed information can be gleaned from them, or electronic scans of them might furnish a good starting point. Only items evidently differing from these drawings would require physical confirmation, when practical. This modified recordation method will minimize the necessity for any of DOE or HAER's staff to physically access the building, thus avoiding most, or all, security and hazard difficulties. HAER also has the capability and extensive experience in using laser-based equipment to scan a wide variety of structures and equipment, should this technology be uniquely appropriate—and acceptable to DOE—for specific aspects of the project, such as the collection of dimensional data where they are not otherwise available outside of significant manual efforts inside the controlled area. With knowledge of available drawings, photographs, and supporting documents, HAER will be well-positioned to prepare a scope and an estimate for such a recordation project and will be pleased to do so if desired.

A considerable amount of non-classified and de-classified documents, both primary and secondary, currently exist regarding most aspects of the Manhattan Project construction and activities, but less is available regarding post-World War II activities under the AEC, NRC, and DOE. The extent to which the DOE can furnish an inventory of its files of unclassified documents and to which it will consider de-classification of documents, when warranted, to make the maximum practical extent of documents relevant to the K-25 building available will inform the interpretive value of historical documentation efforts .

Archival photography of existing conditions can be accomplished by a HAER photographer, or by any other photographer who has access to, and is familiar with using, a 5" x 7" (preferred) or 4" x 5"view camera and accessories. As with the historical text and drawings, it is vital for HAER to be consulted in advance regarding image selection to ensure complete coverage, both in general and in detail. Some existing DOE photographs may suffice to adequately illustrate the existing conditions, and DOE photographs will, at the least, serve as important historic images, especially for features that no longer exist.

Finally, successful interpretation of the K-25 building includes the integration of understandings of the gaseous diffusion process and the technological hurdles overcome by site staff during the war effort with broader contextual treatments. While it is beyond the purview of this report to present an analysis of additional thematic contexts, NPS finds that the significance of the K-25 building merits a comprehensive interpretive plan that examines the building within the broader context of the Manhattan Project, both within the ORR and within the endeavor represented at other "signature" sites throughout the United States. While existing interpretive media at AMSE and the New Hope Center present some contextual material for the Oak Ridge Manhattan Project, these exhibits do not adequately convey the physical and technological relationships among ORR's three industrial sites. The "hub and spoke" interpretive approach mentioned in various reports and currently endorsed in the DOE's Final Mitigation Plan will likely address some of the redundancies and deficiencies of the current interpretive facilities. However, NPS encourages the DOE and its consulting parties also to explore additional site-specific strategies for the interpretation of the K-25 Site during World War II and in post-war contexts, both military and civilian.

Important war-time and post-war themes, as with the interpretation of the gaseous diffusion process, likely are best served through the experience of "authenticity." For example, the interpretation of war-time workers' experience of the Secret City suggests that the Happy Valley site and the security perimeter should be considered as part of the interpretation of the K-25 Site. Appropriate interpretive strategies could include the preservation of significant resources, including Portal 4 (K-1028-45), and a broad range of vehicles (e.g. building and driving tours, virtual tours, interpretive waysides at strategically placed points and overlooks, placement of viewing towers) to interpret the K-25 Site's broader cultural landscape. Similarly, comprehensive interpretative planning should include the K-25 Site's post-war context(s) and identify resources, such as the K-1307 Barrier Plant, that are critical to an understanding of the site's scientific and technological significance in the atomic age.

Summary of Recommendations

- Retain the maximum practical amount of the original building and equipment to enable the best possible interpretation of this facility and its operations:
    - At minimum, this includes retention of a two-cell representation of the K-25 repeating pattern, including at least the three functional levels of the building and the associated process equipment and ancillary fixtures
    - Retention of the exterior wall of the North End Tower will confer a sense of mass and volume that is otherwise unavailable

    - Retention of the original K-25 slab foundation will provide a sense of building scale

- Complete documentation of the K-25 building by a Level I Historic Documentation Program

- Complete a comprehensive interpretive plan that situates the K-25 building within the broader ORR cultural landscape and within World War II and post-war contexts, both military and civilian

<u>Principal Documents Considered in Preparation of This Report</u>

Documents reviewed included, but were not limited to, K-25 related materials developed by the Department of Energy, the Tennessee Historical Commission, and the Atomic Heritage Foundation, as well as materials maintained in the NPS's National Historic Landmarks Program files, and the draft (November 2009) and final (September 2010) copies of the NPS's "Manhattan Project Sites Special Resources Study/Environmental Assessment." A list of the other major documents used in developing this Report follows.

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